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14. ABSTRACT

Leveraging robotic, autonomous, or unmanned technologies in life-saving roles presents great opportunities for the U.S. Department of Defense (DoD). Autonomous systems are emerging, and technology is evolving at a staggering rate across a variety of warfighting domains. The speed that military medical technologies are emerging requires policy makers, requirements directorates, and medical administrators to adapt doctrine and revise legacy policies to keep pace. There are Science and Technology (S&T) advances in Robotic Autonomous Systems (RAS) technologies currently underway that will provide the DoD with a greater capacity to save lives on the battlefield or at sea. These technologies range from autonomous sea, air, and land vehicles to robotic surgical devices. There are moral, legal, and ethical barriers to resolve before RAS can contribute to future strategies. This essay will present an ethical foundation that provides context and understanding so that leaders in DoD medicine can confidently move forward with emerging military medical technology strategy, which enables the use of robotic, autonomous, and unmanned systems in dirty, dangerous, denied, and disaster scenarios.

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The Ethics of Robotic, Autonomous, and Unmanned Systems Technologies in Life-Saving Roles

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Department of the Army Civilian

A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Ethics and Emerging Military Technologies Graduate Certificate Program.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Army.

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Abstract

Leveraging robotic, autonomous, or unmanned technologies in life-saving roles presents great opportunities for the U.S. Department of Defense (DoD). Autonomous systems are emerging, and technology is evolving at a staggering rate across a variety of warfighting domains. The speed that military medical technologies are emerging requires policy makers, requirements directorates, and medical administrators to adapt doctrine and revise legacy policies to keep pace. There are Science and Technology (S&T) advances in Robotic Autonomous Systems (RAS) technologies currently underway that will provide the DoD with a greater capacity to save lives on the battlefield or at sea. These technologies range from autonomous sea, air, and land vehicles to robotic surgical devices. There are moral, legal, and ethical barriers to resolve before RAS can contribute to future strategies. This essay will present an ethical foundation that provides context and understanding so that leaders in DoD medicine can confidently move forward with emerging military medical technology strategy, which enables the use of robotic, autonomous, and unmanned systems in dirty, dangerous, denied, and disaster scenarios.

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Introduction

Leveraging robotic, autonomous, or unmanned technologies in life-saving roles presents great opportunities for the U.S. Department of Defense (DoD) to retain the medical support overmatch to a wide range of threats. Autonomous systems are emerging, and technology is evolving at a staggering rate across a variety of warfighting domains. The speed that military medical technologies are emerging requires policy makers, requirements directorates, and medical administrators to adapt doctrine and revise legacy policies to keep pace. There are significant Science and Technology (S&T) advances in Robotic Autonomous Systems (RAS) technologies currently underway that will provide the DoD with a greater capacity to save lives on the battlefield or at sea. These advanced technologies range from autonomous unmanned sea, air, and land vehicles to robotic surgical devices. There is great potential for leveraging RAS to help save lives in denied, dirty, dangerous, or disastrous scenarios (D^4Scenarios). These capabilities will reduce risk to the warfighter and will extend a pathway to survival when no other options exist.

Despite the promise of these technological advances, there are non-technical barriers to overcome before employing RAS in life-saving roles can become a reality. There are social, legal, ethical, philosophical, and professional obstacles that the DoD must address by educating leaders, creating innovative policies, evolving capability requirements, and adopting transformative Concepts of Operations (CONOPS). Among these, there is a need to shape an ethical foundation that aids in building trust, establishes new policies that will satisfy the legal and ethical requirements, and will instill confidence among leaders who will create new policies to employ these systems in a meaningful way.

Imagine if….

…There was a robotic ground vehicle that could navigate through heavy enemy fire to retrieve a wounded Soldier safely carrying them to the nearest medical aid … DANGEROUS

… or if there was an unmanned sea vessel that could be launched into a dark and stormy night during treacherous seas to conduct a search and rescue for a missing Sailor who was lost at sea thus, mitigating risk to the ship's rescue crew….. DANGEROUS

…There was an autonomous aerial vehicle that could safely extract a wounded Marine with life-threatening injuries from an urban environment in weather so poor that traditional air evacuation assets could not respond...… DANGEROUS

… we developed an unmanned autonomous vehicle that could deliver crucial medical supplies, including blood products, to injured troops pinned down in an urban firefight, where traditional medical resupply capabilities are not able to reach them…. DENIED

…There was a dirty bomb in a large city where hundreds of people are wounded and in need of medical care, basic provisions for survival, or evacuation. In response, teams of air and land autonomous systems respond to deliver food and water, medical supplies and shuttle the wounded to decontamination points and recovery personnel…… DIRTY & DISASTEROUS

And imagine if lives are lost because we are simply unwilling to use such technological capabilities in the future…..

Adapted from the Defense Science Board's Summer Report on Autonomy Concept[1]

This discussion will begin by focusing on a few key assumptions that narrow the premise of using autonomous systems in life-saving roles, it will then review the current policies, ongoing revolutionary S&T efforts that are opening up new frontiers, and how policy makers can better understand trust in automation. Also, a case study will be used to help establish context and understanding for using RAS in casualty evacuation scenarios. Next, the ethical, moral, and legal implications will be described and applied to the case study scenario with a practical

[1] Office of Defense Science Board, *Report of the Defense Science Board Summer Study on Autonomy, June 2016*,

Office of the Under Secretary of Defense for Acquisition, Technology and Logistics Washington, D.C.,4.

assessment framework that helps scope the challenges, understand the risk, and exemplify the opportunities that RAS technologies offer. This project will argue that leaders in DoD medicine can confidently move ahead with future military medicine strategies and policies strengthened by a strong ethical framework, which justifies the use of robotic, autonomous, and unmanned systems in D^4 Scenarios.

Key Assumptions and Definition of Terms

This chapter is intended to establish two basic assumptions and to provide doctrinal definitions that serve to narrow and clarify the discussion. First, assume that before use, advances in RAS will have been evaluated in accordance with all engineering requirements and passed the spectrum of DoD test and evaluation certification criteria. Second, assume that all rigorous doctrinal, organizational, training, materiel, leadership, personnel, facilities, and policy (DOTMLPFP) analysis are completed. In addition, it is important to distinguish the difference between the terms Medical Evacuation (MEDEVAC) and Casualty Evacuation (CASEVAC). According to Joint Publication 4-02, Doctrine for Health Service Support in Joint Operations, Medical Evacuation (MEDEVAC), "traditionally refers to USA, USN, USMC, and USCG patient movement using predesignated tactical or logistic aircraft (both fixed-wing and rotary-wing), boats, ships, and other watercraft temporarily equipped and staffed with medical attendants for en route care."[2] Casualty Evacuation (CASEVAC) "is a term used by all Services, refers to the unregulated movement of casualties aboard ships, vehicles, or aircraft to and between medical treatment facilities."[3] CASEVAC assets, ranging from ground vehicles to cargo helicopters, are non-medical assets available at the time as the only means for field-expedient

[2] Joint Pub, 4-02, *Doctrine for Health Service Support in Joint Operations*, July 26, 2012, I-6.
[3] Joint Pub, 4-02, B-1.

movement of a casualty. These assets are under the purview of ground commanders, not the medical evacuation community.[4] Thus, having established that RAS has met and satisfied these requirements and equipped with an understanding of the terms MEDEVAC and CASEVAC, going forward the discussion will sample various policies and concepts, followed by the ethical, moral, and legal argument for leveraging the RAS in the future.

Defense Concepts of Operation and Governing Policies

Numerous defense agencies are creating strategies, policies, and provisional Concepts of Operation (CONOPS) to address the use and requirements for autonomous systems in life-saving functions. A brief sampling of these efforts follows. The Joint Staff and service components have authorized robust research, test, development, and engineering (RTD&E) and science and technology (S&T) investigations focusing on assessing the maturity level of the technology and exploring future concepts.

1. The Joint Staff has published the Joint Concept for Robotic and Autonomous Systems (JCRAS) concept. The document describes the vision of future robotic and autonomous systems (RAS) to be in use by 2035 and guides their development across the Joint Force.[5] This concept envisions a future Joint Force that capitalizes on technological advances to embed highly capable and interconnected RAS into every echelon and formation. Employing RAS in the future will be characterized by the following precepts:
   - Employ Human-RAS teams
   - Leverage autonomy as a key enabler

[4] Paul Scharre, *Left Behind: Why It's Time to Draft Robots for CASEVAC*, War on the Rocks Commentary, August 12, 2014, accessed November 15, 2016, http:warontherocks.com/2014/08/left-behind-why-its-time-to-draft-robots-for-casevac.

[5] Chairman of the Joint Chiefs of Staff, *Joint Concept for Robotic and Autonomous Systems*, 19 October 2016, Forward.

- Integrate RAS capabilities to develop innovative concepts of operations[6]

Some of the uses that the JCRAS describes are "autonomous pods providing immediate medical evacuation capability, medical evacuation and resupply."[7] The report goes on to cite the following vignette:

> "Interconnected Human-RAS teams will automate many logistics functions, from warehouse management to transportation to sustaining a forward operating base, improving the tooth-to-tail ratio and efficiency. RAS casualty evacuation, en route care, and even life-saving surgery have the potential to revolutionize joint medical operations."[8]

2. The U.S. Army Medical Department (AMEDD) has drafted policy that foresees that RAS has the potential to provide the Army with key decisive advantages over future adversaries.[9] Notably, the AMEDD has the most mature effort across the components having led research efforts investigating the use of robotics and unmanned aerial vehicles for casualty evacuation for the past nine years. Representatives from U.S Army Medical Command (MEDCOM), including this author, helped pen NATO's Research Technology Group (RTG) - 184's "*Safe-Ride Standards for Unmanned Casualty Evacuation Using Unmanned Aerial Vehicles Report*" (NATO RTG-184 Report) in 2012. Much of the Army's strategies for using unmanned systems in evacuation roles cite this report as their foundational framework for guiding the unmanned Casualty Evacuation (CASEVAC) CONOPS. The NATO RTG-184 Report describes a core set of safety standards

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[6] Chairman of the Joint Chiefs of Staff, *Joint Concept for Robotic and Autonomous Systems*, 19 October 2016, 22.
[7] Ibid.
[8] Ibid., 8.
[9] DRAFT Army Medical Department (AMEDD*) Position for the Employment of Robotics and Autonomous Systems (RAS) in support of the Army RAS Strategy*, February 03, 2017.

governing the design of unmanned aerial cargo vehicles that will likely be utilized for opportunistic CASEVAC in the future. If, and when, such an event occurs, this report provides design considerations that will increase patient survivability and safety while aboard the unmanned system.

The AMEDD has also drafted a Robotic and Autonomous Systems (RAS) Strategy that will address RAS activities intended to create opportunities for collaboration and looks to using RAS to mitigate resources constraints.[10] According to a 2016 draft AMEDD Information Paper, "The Army endstate in RAS development is to increase the combat effectiveness of the future force and to maintain overmatch in combined arms operations against capable enemies."[11] The Army Medical Department is developing requirements based upon doctrinally identified capability gaps, as noted in TRADOC PAM 525-66, Future Operating Capability 09-06, Health Services Support. This pamphlet states,

> "Future Soldiers will utilize unmanned vehicles, robotics and standoff equipment to recover wounded and injured Soldiers from high-risk areas, with minimal exposure to recover wounded Soldiers and facilitate immediate evacuation and transport."[12]

Although no yet approved, it is clear that the AMEDD is ambitiously drafting new policies that are focusing on the near, mid, and long-term integration of RAS in life-saving roles. The AMEDD's goal is in part to increase the survival rates of wounded Soldiers using RAS technologies, improve medical resupply capabilities, and most admirably, it aims to, "meet all

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[10] DRAFT Army Medical Department (AMEDD), *Position for the Employment of Robotics and Autonomous Systems (RAS) in support of the Army RAS Strategy*, February 03, 2017.
[11] Ibid.
[12] Department of the Army, *TRADOC Pamphlet 525-66, FORCE OPERATING CAPABILITIES*, Headquarters, United States Army Training and Doctrine Command Fort Monroe, Virginia, March 07, 2008, 129.

doctrinal, moral, legal and ethical standards for casualty treatment and evacuation."[13] One example of a robotic medical device that represents a near-term capability is the DaVinci Surgical System, designed by Intuitive Surgical. The system was conceived for conducting surgical procedures in harsh battlefield environments and uses telerobotic surgical devices that provide precision and stability for the operating physician. One can envision combining the attributes a telerobotic surgical device with a RAS for accessing and treating a patient in a denied environment.

Figure 1. DaVinci Robotic Surgical System, Intuitive Surgical, Inc.

In addition to telerobotic systems, the AMEDD's mid- and long-term vision for utilizing RAS technologies is also very promising. Their plan envisions the development of emerging RAS technologies for CASEVAC, and for the movement of pharmaceutical and blood products to the point of injury.[14] Lastly, the AMEDD`s long-term vision is to provide requirements for

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[13] DRAFT, *Army Medical Department (AMEDD) Position for the Employment of Robotics and Autonomous Systems (RAS) in support of the Army RAS Strategy*, February 10, 2017.
[14] Ibid.

RAS ground and air ambulances that can assist with en route care and improve the "operational capability of the medical evacuation (MEDEVAC) platforms and medical providers."[15]

3. The U.S. Air Force's Medical Operations in Denied Environments Operational Concept relays the Air Force's intent to "lay a foundation for organization, training and equipping of medical personnel forces to provide the means available and therefore enhance the ways that Geographical Combatant Commanders and component planners script their plans to counter an Anti-Access, Area-Denial (A2/AD) threat."[16] The Air Force CONOPS (Fig. 2) addresses the issue of accessing the wounded in denied environments utilizing autonomous unmanned aerial systems.

Figure 2. USAF CONOPS for Patient Evacuation in Denied Environments[17]

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[15] DRAFT Army Medical Department (AMEDD) *Position for the Employment of Robotics and Autonomous Systems (RAS) in support of the Army RAS Strategy*, February 10, 2017.
[16] Office of the Air Force Surgeon General, *Medical Operations in Denied Environments Operational Concept*, November 02, 2015, 18.
[17] Ibid.

4. The U.S. Navy's Office of Naval Research's (ONR) Autonomous Aerial Cargo/Utility System (AACUS) is one example of the Navy's desire to identify unmanned cargo platforms for patient evacuation. AACUS is an Innovative Naval Prototype (INP) program that is exploring advanced autonomous resupply in the near-term and, casualty evacuation in the long-term. AACUS features autonomous obstacle avoidance, landing zone selection, communications with ground personnel and will operate under supervisory control of any operator, requiring no specialized training.[18] Also, ONR is investigating technologies that can mitigate the tyranny of time and distance on patient survival. For example, there are studies examining a simple, all-inclusive, lightweight mobile system designed to fit under the patient litter called Autonomous Patient Critical Care (ACCS).[19] According to ONR, "ACCS (Fig. 3) offers continuous monitoring of a patient's physiological state, allowing immediate detection of adverse changes in their medical status and thus faster life-saving interventions. The system affords appropriate intervention and control in the absence of a skilled caregiver and reduces manpower and logistics demand."[20] In addition, ONR states, "the systems will help to maintain a critically injured / ill patients for minimum of 2-6 hours without degradation in clinical status and is designed to provide ventilation, IV fluids/drugs, and patient monitoring" during CASEVAC.[21]

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[18] Chief of Naval Operations, *U.S. Navy Program Guide, 2013*, Section 7, 168.
[19] Office of Naval Research, Program Code 34, Automated Critical Care System Fact Sheet, www.onr.navy.mil.
[20] Ibid.
[21] Ibid.

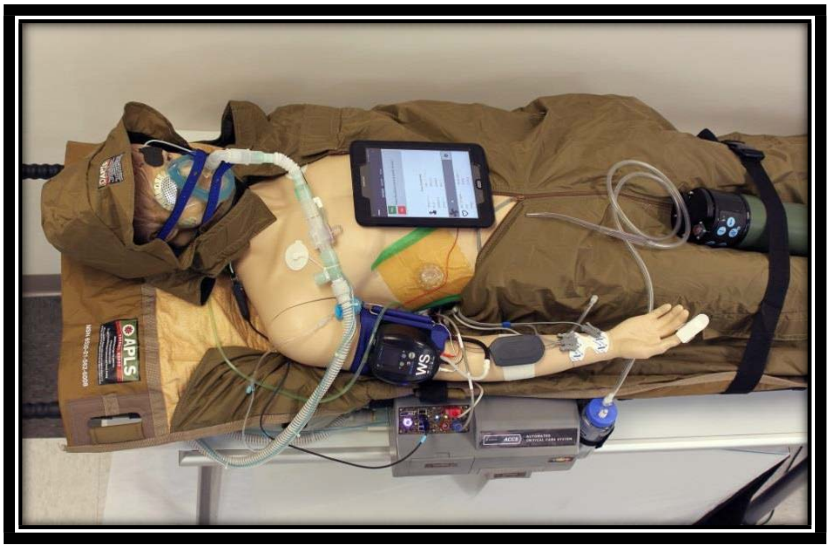

Figure 3. Office of Naval Research's Automated Critical Care System (ACCS)

Figure 4. Boeing's Unmanned Undersea Cargo Vehicle, "Echo Voyager."[22]

In the future closed loop automated patient care systems like ACCS could conceivably be merged with autonomous unmanned undersea vehicles like Boeing's Echo Voyager (Fig. 4) to deliver relief supplies or possibly provide CASEVAC from extreme weather (austere) environments, such as the Arctic.

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[22] Boeing's *Echo Voyager* photo, accessed May 19, 2017, http://www.boeing.com/features/2016/03/bds-echo-

voyager-03-16.

In summary, this chapter provides a synopsis of the policies and CONOPS of the Joint Staff and DoD components. These policies and CONOPS demonstrate that each component is postured towards a future that leverages the benefits of autonomous systems in life-saving roles. Lastly, there are a plethora of definitions for the phrase "trust in automation" therefore, it is important to frame those terms and provide context for employing RAS in D^4 Scenarios.

Trust in Automation

It is essential to understand what "trust" signifies as a basis for using RAS for life-saving functions. Trust is often discussed concerning using weaponized robots and autonomous systems. According to Dr. Langdon Winner, Thomas Phelan Chair of Humanities and Social Sciences at Rensselaer Polytechnic Institute, "of primary importance, is to establish an understanding that technology itself should neither be trusted nor distrusted, that it is inherently neutral, and too often society relates this moral construct to the technology itself."[23] Winner states, "Technology is nothing more than a tool and what men do with tools is *use* them. The tool itself is completely neutral - a means to the desired end. Whether the end accomplished is wise or unwise, beautiful or hideous, beneficial or harmful, must be determined independently of the instrument employed."[24] Winner provides this helpful explanation, which extracts the moral construct of trust from the tools we employ to accomplish a task and places trust on *people*. Thus, according to Winner, "it is important to grasp that regardless of their size or complexity of

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[23] Langdon Winner, *Autonomous Technology, Technics Out-of-Control as a Theme in Political Thought*, MIT Press, 1977, 27.
[24] Ibid.

the tool, or how well or poorly we use it to accomplish a task, it is those who *employ* autonomous technologies that must be trusted, not the technology itself."[25]

Therefore, having detached the moral construct of trust from the autonomous system we will examine two definitions of trust that are helpful in providing greater context and understanding. First, researchers Kevin Anthony Hoff and Masooda Bashir of the University of Illinois define trust as, "something the human requires when something is exchanged in a cooperative relationship characterized by uncertainty."[26] Second, the U.S. Defense Science Board Summer Report on Autonomy states "Trust is something that commanders must have, which is a confidence that the autonomous functions will operate as intended."[27] Taken together, these definitions best express the dynamics modern warfare. Namely, where there is a high potential for unforeseen events and a high degree of risk, there is the necessity for the commander to have a trustworthy-cooperative relationship with the robotic, autonomous, or unmanned system.

To provide an even greater understanding of the relationship between trust and the autonomous systems it is important to understand how *automation* is frequently defined. According to University of Iowa, researchers, automation is, "technology that actively selects data, transforms information, makes decisions, or controls processes."[28] Thus, automated systems may be designed to perform tasks that may be too complex for humans; in some cases, these may

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[25] Langdon Winner, *Autonomous Technology, Technics Out-of-Control as a Theme in Political Thought*, MIT Press, 1977, 27.
[26] Kevin Anthony Hoff and Masooda Bashir, *Trust in Automation: Integrating Empirical Evidence on Factors That Influence Trust*, the University of Illinois at Urbana-Champaign.
[27] Office of Defense Science Board, *Report of the Defense Science Board Summer Study on Autonomy, June 2016*, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics Washington, D.C., 16.
[28] John D. Lee and Katrina A. See, Trust *in Automation: Designing for Appropriate Reliance*, published in Human Factors, Vol. 46, No. 1, Spring 2004, 51.

be repetitive tasks or where they may be employed in life-saving roles, we require a very low incidence of error, a high degree of reliability and precision. To be autonomous, the Defense Science Board states that, "the system must have the capability to independently compose and select among different courses of action to accomplish goals based on its knowledge and understanding of the world, itself, and the situation."[29] Furthermore, there is a distinction to be made between autonomous functions and those that are automated. Automated functions are governed by prescriptive rules that permit no deviations; whereas autonomous systems possess the capacity to make decisions based upon pre-prescribed algorithms.[30] In addition, there are many levels of autonomy, ranging from Level 1 – 10. The most commonly assigned is Level 1, wherein the human is highly involved with the machine and extending to level 10, where autonomy performs the entire task. Lastly, there are options for employing flexible autonomy, which is the ability to adjust the degree of human control over the system. This capability will increase the effectiveness of human autonomous teams and permit operations in a wider variety of applications and environments. When deciding the level of control, the commander considers the system's capabilities and limitations, mission risk and complexity, and selects the characteristics of the autonomy desired for the operating environment.

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[29] Office of Defense Science Board, *Report of the Defense Science Board Summer Study on Autonomy, June 2016*, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics Washington, D.C., 4.
[30] Ibid.,5.

Level	Description
High	10. The computer decides everything, acts autonomously, ignoring the human.
	9. The computer informs the human only if it, the computer, decides to.
	8. The computer informs the human only if asked, or
	7. The computer executes automatically, then necessarily informs the human, and
	6. The computer allows the human a restricted time to veto before automatic execution, or
	5. The computer executes that suggestion if the human approves, or
	4. The computer suggests one alternative
	3. The computer narrows the selection down to a few, or
	2. The computer offers a complete set of decision/action alternatives, or
Low	1. The computer offers no assistance; the human must take all decisions and actions.

*Adapted from an earlier work.[11]

Fig. 5 Sheridan-Verplank Levels of Autonomy Scale[31]

The Defense Science Board's Summer Study on Autonomy states the following regarding autonomy: "Whether mediated by man or machine, all acts, but especially acts related to warfighting must be executed in agreement with policy and so, in some sense, there is no completely autonomous behavior. Any use of autonomy must conform to a substantive command and control regime laying out objectives, methods and express limitations to ensure that autonomous behavior meets mission objectives while conforming to policy."[32] This important distinction establishes that as the human conducts warfighting in compliance with policy and under the provision of substantive ethical employment of their various roles in combat, the corollary is also true, that for the human-machine relationship. Simply put, trusting autonomous systems refers to a person having the confidence that the machine will perform to specifications

[31] Sheridan-Verplank Levels of Autonomy Scale photo grabbed from http://doi.ieeecomputersociety.org/cms/Computer.org/dl/mags/ex/2011/03/figures/mex2011030081t1.gif.

[32] Office of Defense Science Board, *Report of the Defense Science Board Summer Study on Autonomy, June 2016*, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics Washington, D.C.,16.

in the application it is intended but also that the employment of the technology is within the scope norms, laws, rules of engagement, and policy. The following case study illustrates the benefits of using unmanned aerial vehicles for CASEVAC in the context of a D^{4}Scenario that will highlight how emerging life-saving technologies may fulfill these roles.

Case Study Examination of Unmanned Aerial Vehicles in Life-Saving Roles

In the future, it is likely that a soldier might commandeer an unmanned cargo system and use it as a platform for completing an opportunistic casualty evacuation in a crisis. This premise was the driving force behind NATO RTG-184 Report, Safe-ride Standards for Unmanned Systems Casualty Evacuation (CASEVAC) mentioned earlier in this document. This CONOPS envisages using unmanned systems for moving a casualty a short distance from the point of injury to a safer location where initial medical care can begin.

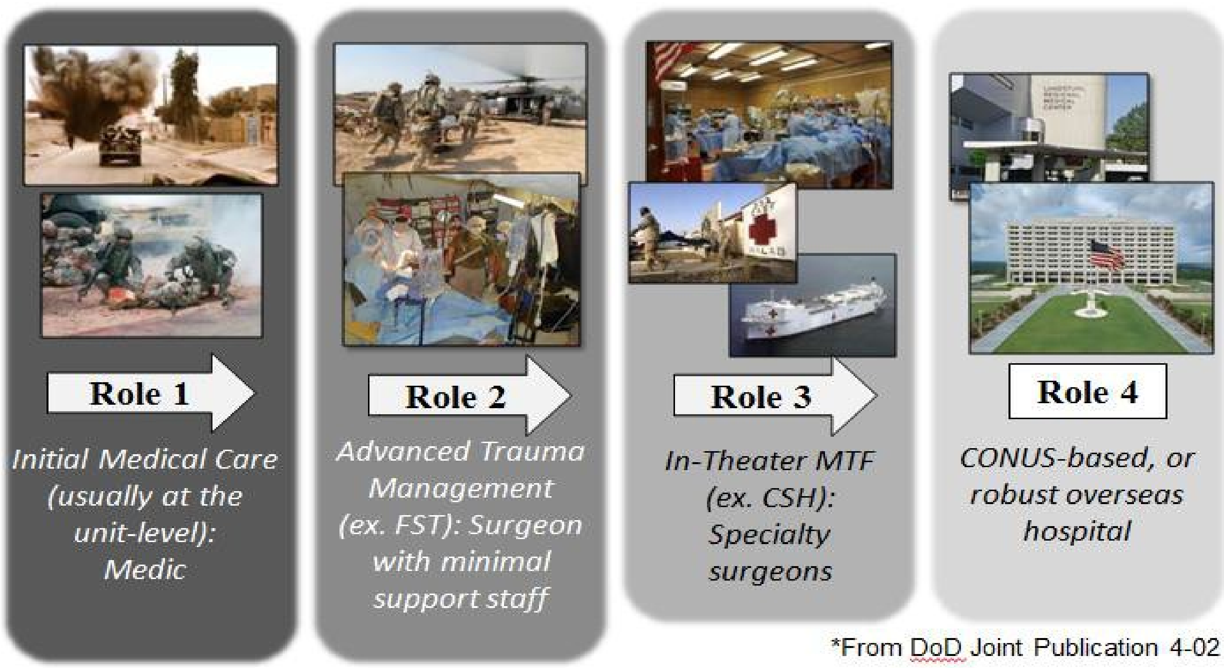

Fig. 6 Levels of Care Chart

Doctrinally, D^4Scenarios may not fit inside of the scope of Role 1 (See Fig 6) medical care, which sets the proper context for using RAS technologies. The CONOPS envisions that within the D^4Scenario context, using an unmanned-autonomous system to evacuate a casualty to a higher level of care is justifiable. What's more, there are formidable societal implications surrounding this future CONOPS, whereas socialization becomes an important first step in the evolutionary process of establishing new societal norms. Using unmanned ground or aerial vehicles for casualty evacuation may evoke a variety of reactions from society, ranging from concerns about the safety and care of the patient, skepticism that the concept is feasible, and in some cases, absolute horror. Even when the critical assumptions are satisfied (legal, moral, ethical, engineering, etc.) there remain hidden fears. These concerns are well meaning, are directed towards protecting the casualty and are not merely unreasoning opposition intended to maintain the status quo. While these concerns can be ameliorated over time, this is not to say that it will be either rapid or easy to do so. This concept of socialization will be an evolutionary development, where trust in the systems and operators grows over time, and new social norms evolve.[33]

Currently, the socialization of emerging technologies for use in civil applications has already begun to populate the airwaves. This process is an important first step for introducing the potential utilization and benefits to society writ large and helps to reduce anxiety by instantiating the concept in the minds of the populace. These uses may still be many years off but it useful to cast the potential benefits and future vision to the populace. Renowned medical historian, Dr. David Lam. M.D. (COL, U.S. Army Ret.) writes this regarding socialization of the concept:

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[33] NATO, STO-Report, *Safe Ride Standards for Casualty Evacuation Using Unmanned Aerial Vehicles*, RTG-184 Technical Report, December 2012, 2-2. Dr. Lam served as Editor in Chief for this report.

In 1903, the possibility of using combustion-driven vehicles to transport casualties from the battlefield was first raised, and before then dogs and horses were the means of locomotion. These ideas were met with cynicism. One critic was heard to say of using a motorized vehicle for casualty transport, "nothing has been found to equal the force of the horse for economy and safety. Patients, being probably in a nervous condition, will be alarmed at the idea of being taken off in a motor car."[34]

Early beginnings of casualty evacuations via dog-drawn, horse-drawn, and motorcycle driven platforms (circa the early 1900s)

Early 20th-century patient evacuation methods.[35]

[34] NATO, STO-Report, *Safe Ride Standards for Casualty Evacuation Using Unmanned Aerial Vehicles,* RTG-184 Technical Report, 2-2. (Dr. Lam reports that the original source is unknown, but clearly indicative of the opinions of the era).
[35] Photographs accessed through various open sources, May 05, 2017, www.bing.com.

Bi-plane evac

Towed trailer evac

Ambulance WWI

Casualty evacuation progression into motorized and airborne platforms (circa 1914)

Unmanned Little Bird (cargo/trauma pods concept)

Kaman Kmax Unmanned Cargo Helicopter

Urban Aeronautics Airmule Design Concept

Cargo rotary wing platforms undergoing operational testing that could be leveraged in a contingency for CASEVAC (2016)

Argodesign - in flight

Argodesign -concept design

Argodesign -accident scene

Future concepts featured here is the Argo-design medical evacuation quad-copter that could conceivably carry a medical attendant and one patient (2025-2035)

Modern era and future medical evacuation concepts.[36]

Society has come a long way from the days that first established using animals and primitive machines to move the wounded. It's okay to imagine that using unmanned systems in this role will stir similar reactions today. It is also likely that over time, these reactions will normalize and the technological capability can reach its potential for helping save lives. Conceptually, the modern era versions of the unmanned systems pictured above could be deployed using full-autonomy, remotely piloted, optionally piloted, or with automated functions, i.e., takeoff and landing. The human-machine interface can be very simple, where autopilot functions could relieve the medical attendant from having to fly the craft, allowing the flight control computer autonomous control of the vehicle and the medical attendant to provide en route care. Below are other examples of how society, through academia and industry, are pressing forward with future uses for drones:

[36] Photos accessed through various open sources, May 05, 2017, via www.bing.com.

- A Dutch University student has developed drones that deliver a flying defibrillator for emergency cardiac assistance. Someone merely calls a hotline, and a drone is dispatched within one minute, and it can transport rescue equipment to someone in need within a 12-kilometer range. The developer even plans on expanding the drone's capacity to carry oxygen masks or even insulin injections.[37] One might envision using this drone to deliver epinephrine for people suffering an anaphylactic reaction to some sort of allergen, like a bee sting.[38]
- German logistic firm, DHL, is testing the concept of delivering medication to patients on the island of Juist located seven miles off the northern German coast. This medication delivery drone can travel the distance in 34-40 minutes at a speed of 40 mph and is constructed to withstand the harsh North Sea weather patterns. These DHL "parcelcopters" could save time and alleviate the need for traveling by boat or aircraft to the isolated location.[39]
- The U.S Army Telemedicine and Advanced Technology Research Center is leveraging a small prototype twin-rotor Unmanned Aerial System (UAS DP-14) to provide a cost-effective research platform for the operational testing and evaluation of emerging en route care and medical resupply technologies.[40]

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[37] Mark Prigg, *The ambulance drone that could save your life: Flying defibrillator can reach speeds of 60mph*, Daily Mail, October 29, 2014, accessed February 14, 2017, http://www.dailymail.co.uk/sciencetech/article-2811851/The-ambulance-drone-save-life-Flying-defibrillator-reach-speeds-60mph.html.
[38] Tim Schultz, Professor, U.S. Naval War College, suggested utilization concept.
[39] Alex Hern, *DHL launches first commercial drone 'parcelcopter' delivery service*, September 25, 2014, accessed, May 20, 2017, https://www.theguardian.com/technology/2014/sep/25/german-dhl-launches-first-commercial-drone-delivery-service.
[40] The Telemedicine and Advanced Technology Research Center, *Emergency Medical Resupply and En route Care Unmanned Aerial System (UAS) DP-14 Research Platform Fact Sheet*, May 15, 2017.

These drone technologies are rapidly maturing, providing society the ability to envisage their value and potential uses in saving lives. To ensure that the DoD is poised to leverage these types of emerging military medical technologies, a framework is presented that provides an ethical, moral, and legal basis that will help to guide innovative policies for their employment.

The Moral Argument

The overarching principle of this document makes the case that leaders in DoD medicine have a fundamental moral obligation to utilize robotic, autonomous, and unmanned systems technologies in life-saving roles within the context of D^4Scenarios. Guided by several directorial principles, quite admirably, the healthcare community already operates within precisely these kinds of substantive moral and ethical norms every day. The healthcare community is governed by esteemed practices such as moral self-governance, and other philosophical principles that define their professional ethos.[41] These philosophical and ethical principles are the moral and legal norms that bound their duties, such as the *Hippocratic Oath*. According to Dr. George Lucas, Visiting Distinguished Research Professor at the John J. Riley Center for Science, Technology and Values at the University of Notre Dame, "these are the foundational principles that are universally adhered to and are commonly held conceptions that form the basis of *doing good*."[42] According to Professor Lucas, "In contrast, healthcare professionals may reflect in the aftermath of their uncharacteristic calamities of malpractice or malfeasance at venues like Nuremberg, Belmont, or Helsinki to find examples of moral self-governance at work in the

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[41] George Lucas, *Ethics, and Cyber Warfare, The Quest for Responsible Security in the Age of Digital Warfare,* Oxford University Press, September 06, 2016, 95.
[42] Ibid. 95.

present."[43] These events highlight why medical professionals must operate under tightly governed ethical, normative codes today that serve to protect vulnerable populations, care for the wounded and sick, and first above all, *do no harm*.[44]

It is within the scope of these norms that new policies must evolve that contextualize, justify, and exemplify this regard for *doing good by extension*, through the use of robotic, autonomous, and unmanned systems technologies. It is argued here, that a "moral imperative" exists for commanders who are acting justly, to use all practical means that technology affords to save lives.[45] The ethical obligation argument to advocate for the use of robotic, autonomous, or unmanned systems is based upon a framework of guiding principles that helps to create a defensible ethical stance. The Markkula Center for Applied Ethics at Santa Clara University has published a framework for making ethical decisions; these were selected for their simplicity and are used to guide decisions makers who are responsible for designing future policies. It begins by asking the following series of questions:

1. Is there an ethical issue? Could the decision to use a RAS be harmful to someone or a group? Does using the RAS in this role present a choice between a good and bad alternative? Is the issue about what is legal or what is most efficient?

a. Does the example of using an unmanned system in a casualty evacuation role present more harm than leaving the wounded behind?

b. Are there concerns regarding the continuity of care? If so, are there technologies that can intervene to solve this dilemma?

[43] George Lucas, *Ethics, and Cyber Warfare, The Quest for Responsible Security in the Age of Digital Warfare,* Oxford University Press, September 06, 2016, 95.
[44] Ibid.
[45] Bradley Jay Strawser, *Moral Predators: The Duty to Employ Uninhabited Aerial Vehicles,* Journal of Military Ethics, Vol. 9, No. 4, 342368, 2010, 343.

2. Have alternatives actions been evaluated?

a. Which options present the most good and will do the least harm?

b. Which option takes into consideration the rights of who is a stake?

c. Which option treats people equally or proportionately? For example, if we fail to recover the wounded by way of a RAS, could this be considered unjust to the wounded individual? Is this in itself a form of patient abandonment?

d. Which option best serves the common good of the community as a whole, not just some member? For example, unit morale is of vital importance; there may be psychological consequences to the group if we fail to exercise all available means to recover an injured teammate.

e. Which option leads me to act as the sort of person I want to be, referred to here as the "virtue approach"? Healthcare professionals in the DoD live sacrificially for one another, they epitomize the highest virtues of selfless service, duty, and honor. If someone's life could have been saved by using RAS when the alternative is leaving a wounded warfighter behind, one would likely choose to attempt the recovery by using all available means possible.

3. Decide, Act, and Re-evaluate:

a. With consideration to all the available options, which option best addresses the situation?

b. If you were to explain your decision to use a RAS in a life-saving role what would you say? Can you justify using this alternative? (Defensible Ethical Stance)

c. How can my decision to act be implemented with the greatest care and attention to all the concerned stakeholders, primarily the wounded in need of recovery?

d. How did my decision turn out? Was the patient recovered safely? If not, why? How could I have acted differently? What can be learned from the situation?

There are many ways of discussing the moral argument, though not comprehensive, these principles were chosen based upon their applicability to the ethos of modern warfare. In my view, there are three primary principles of this argument: the Principles of Unnecessary Risk, Necessity, and Immediacy. First, we shall discuss the Principle of Unnecessary Risk that applies to the first responders under the umbrella of force protection. This is not an argument about excessive safety; it is more about using technology in extreme circumstances that could save the life of a victim without sacrificing the caregiver. In this case, the commander has determined that responders would be placed in grave danger should they attempt a casualty evacuation in a D^4Scenario, which would therefore justify using a robotic, autonomous, or unmanned system. In essence, it has been established that for any number of reasons, the risk outweighs the reward. The *Utilitarian Principle* supports this concept, whereas, there is an unacceptably high risk of killing or injuring a greater number of people by performing the recovery than would be lost by not attempting the action.[46]

The second is the Principle of Necessity. This principle is applied as the last resort contingency principle. Given the dire circumstances, no other option exists, leaving the commander to attempt the recovery by utilizing a RAS. Otherwise, all hope of recovering the wounded patient would be lost.

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[46] Utilitarianism is generally held to be the view that the morally right action is the action that produces the most good. On the utilitarian view, one ought to maximize the overall good — that is, consider the good of others as well as one's own good. Stanford Encyclopedia of Philosophy, accessed May, 25, 2017, https://plato.stanford.edu/entries/utilitarianism-history/

The third is the Principle of Immediacy. This principle applies when there are no other available resources (traditional ground, sea, or air evacuation capabilities) and time is of the essence. The commander would be justified leveraging a RAS to retrieve the wounded. This principle is supported by the *Deontological Principle*, which suggests that it is *our moral duty to respond* as quickly as possible.[47]

There are other supporting concepts that may provide justification and strengthen the basic argument of these principles. The supporting concept of proportionality is derived from law and is generally applied to using lethal autonomous systems. The principle of justice, benefice, and the rights approach are frequently cited when arguing against using unmanned systems technologies for casualty evacuation. However, for this argument, these terms and principles have been re-conceptualized for justifying the use of RAS in D^4Scenarios.

Proportionality: In this example, gaining the goods (a wounded human's life) is worth the effort that is expended. Since a human life is at stake, the commander would expend all practical resources available to effect the safe recovery of the wounded person, including the use of a RAS. The RAS may be the most feasible and proportional option given economy of force, availability of recovery assets, and risk management considerations. In conjunction with the Principle of Unnecessary Risk, the Utilitarian Principle, and the Principle of Necessity, it would be prudent to use an equivalent amount of resources, in this case a RAS, to execute the recovery mission while balancing the risk/reward calculus.

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[47] Deontologists believe that morality is a matter of duty. We have moral duties to do things which it is right to do and moral duties not to do things which it is wrong to do. Whether something is right or wrong doesn't depend on its consequences. Rather, an action is right or wrong in itself. Found at Routledge, Taylor and Francis Group, Kant's Deontological Ethics, Deontology definition, accessed May 25, 2017, http://documents.routledge-interactive.s3.amazonaws.com/9781138793934/A22014/ethical_theories/Kant%27s%20deontological%20ethics.pdf

Justice: *Justice* in my view describes the virtuous actions of the commander who is exercising all the available means with the intended benefit to the wounded. The principle of justice generally considers a sense of "fairness in distribution" or "what is deserved."[48] Injustice would be denying the potential benefit of using a RAS to save someone in a D^4Scenario without good reason.

Beneficence: Refers to actions that do not simply avoid harm or the intention of harm, as above, but actively promote the positive well-being of others. For example, intending to use a RAS in extreme circumstances where traditional rescue/recovery assets are unavailable to benefit a wounded person in need of extraction. In the armed services, this act to promote the well-being of the injured person may promote a sense of confidence in battle.[49]

Rights Approach: This principle considers patient rights, basic humanitarian rights, and natural rights. For example, according to the World Health Organization, patient's rights, "recognizes the inherent dignity and the equal and unalienable rights of all members of the human family. In other words, what is owed to the patient as a human being."[50] It is argued that wounded service members in D^4Scenarios have the basic right to be recovered by the use of RAS, especially when no other options exist.

Furthermore, this presentation has described the overarching substantive norms that establish the moral argument and provides the *context* for using autonomy in life-saving roles. One final analysis framework is offered that can assist policy makers in assessing the *operational*

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[48] Office of the Secretary Ethical Principles and Guidelines for the Protection of Human Subjects of Research, *The Belmont Report*, The National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, April 18, 1979, accessed May 25, 2017, https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/index.html#xbenefit.
[49] Tim Schultz, Professor, U.S. Naval War College.
[50] The World Health Organization, Genomic Research Centre, *Patient's Rights*, accessed June 08, 2017, http://www.who.int/genomics/public/patientrights/en.

context for using RAS in D^4 Scenarios. This operational analysis framework asks important questions that can guide the rational decision maker toward the best possible course of action, called here the Six A's for Ethical Questions:

1. Application – how will the RAS be used, i.e., search and rescue, CASEVAC, medical resupply? Does the crisis warrant its use?
2. Accountability – who is deploying the RAS? Who owns it? Who is controlling it? Who is making the decision to use the RAS? Is this the Combatant Commander, theater commander, unit commander, area medical commander or the unit medic? Ultimately, policies will determine where the authority rests to launch the RAS.
3. Alternatives – Are there traditional assets to employ? If not, what RAS are available?
4. Achievability – Is the RAS able to achieve what it is designed to do, are there extenuating circumstances that would prevent the system from achieving its design objectives? Has the RAS been utilized in this capacity before?
5. Autonomy level – Are there options for supervised or flexible autonomy? What mode poses the least amount of risk and the greatest chances of mission accomplishment: fully autonomous or some level of human-in-the-loop?
6. Assessment of Risk – What metric is used to determine the risk for deploying the RAS? Have all the operational risk mitigation methods been examined?

Some might argue that this moral argument neglects such issues as continuity of care, patient abandonment, and non-malfeasance. It is an ethical and doctrinal requirement that once medical care has begun that this process continues until the patient reaches the next higher level of attention. Loading a patient on an unmanned system represents a break in the chain of care. Also, if a medic were rendering care and then loaded the unaccompanied patient on an unmanned system, this would be tantamount to patient abandonment, which is also unethical. Lastly, some might argue that the risk of placing the patient aboard an unmanned system represents malfeasance. The ethical principle of non-malfeasance attempts to avoid any act or treatment that could cause harm to the patient, which otherwise would violate the medical ethos of “first, do no harm.” This point argues that in the near term intentionally placing the patient aboard an unmanned system could be dangerous. According to the Federal Aviation Administration, between 21% and 68% of unmanned aerial systems accidents involve human error and of those, electromechanical failure was even more of a causal factor.[51] Until such time that continuity of care, patient abandonment, and RAS safety is assured, using these systems in D^4Scenarios should be postponed.

On the other hand, the exponential growth of telemedicine, telerobotic, and automated critical care systems that could be used aboard an unmanned system may solve the continuity of care dilemma. For example, ONR’s ACCS system is a litter mounted en route care device that could ventilate a patient through closed-loop controls, buying just enough time to transport the wounded to the next level of care. Patient abandonment could be solved by using robotic care devices mentioned previously, or also by ensuring that future platforms have a station for a medical attendant to ride along. Lastly, unmanned systems technologies are maturing at a staggering rate. As systems reliability improves and CONOPS mature, the safety of these systems will improve as well. According to the U.S. Air Force Safety Center, unmanned aircraft

[51] Kevin Williams, *A Summary of Unmanned Aircraft Accident/Incident Data: Human Factors Implications,* Civil Aerospace Medical Institute, Federal Aviation Administration, Oklahoma City, December 2004.

trends are improving because of experience and continuous systems improvements.[52] Furthermore, one may consider the *Feres Doctrine* to abate malfeasance claims. The Feres Doctrine is a legal code that according to the Cornell Law School "prevents people who are injured as a result of military service from successfully suing the federal government under the Federal Tort Claims Act."[53] The Feres Doctrine would relieve the commander, as representative of the government, from lawsuits stemming from the use of RAS in D^4Scenarios. Therefore, in light of this defensible ethical stance, it is important that decision makers begin to scope new policy that will ensure that when the technology capability arrives that all legal, moral, and ethical conundrums are presciently addressed.

Third-Offset Policy Strategies for DOD Medicine

Commanders in the 21st century are facing challenging socio-political times exacerbated by threats from violent extremist organizations, growing regional hegemons in Southeast Asia, European instability, and mounting global humanitarian calamities. These leaders look to the benefits of emerging military medical technologies against the backdrop of turbulent economic times. Emerging medical technologies represent the materiel agents of transformation that the future medical force will rely upon. Thus, medical component's strategies must be poised to discover new capabilities, develop innovative concepts, and seek out economic solutions that optimize the effectiveness of our fighting forces.[54]

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[52]Darlene Y. Cowsert, *Safety at center of growing RPA requirement*, Air Force Safety Center Public Affairs, September 11, 2012 accessed May 21, 2017, http://www.safety.af.mil/News/Article-Display/Article/434414/safety-at-center-of-growing-rpa-requirement.
[53]"Cornell Law School, *Feres Doctrine*, Definition from Nolo's Plain-English Law Dictionary, Legal Information Institute, accessed May 21, 2017, https://www.law.cornell.edu/wex/feres_doctrine.
[54] United States Army Medical Command (USA MEDCOM) and the Office of The Surgeon General (OTSG), *The Army Medicine Campaign Plan (AMCP) 2017*, November 03, 2016.

Advances in autonomous intelligence, robotic, and unmanned technologies will help commanders overcome the fog and the friction of 21st-century wars. Leaders will require enhanced situational awareness tools, real-time intelligence information and communication capabilities, and extended reach that autonomous systems can provide to win in operational environments characterized by volatility, uncertainty, complexity, and ambiguity. The following are some examples of future technology concepts for DOD Medicine. Some of these technologies are presently under research and development while others are merely conceptual:

1. Medical evacuation via autonomous pods attached to aerial or ground platforms, which provide quick evacuation capabilities in disastrous (mass casualty) and denied scenarios (dirty bomb and/or A2/AD).[55]
2. Undersea autonomous systems that help gain access to the wounded and transport them to medical care clear of austere or denied environments.
3. RAS that can assist in providing life-saving interventions in D^{4}Scenarios.[56]
4. Telemedicine, telepresence, and telerobotic devices that can extend the physician's reach aboard unmanned systems.

Another essential part of conceptual Third Offset Policy Strategies for DOD Medicine is for leaders to scope guidelines ahead of the pace of the technology innovations. This project suggests that DoD leaders must become better "Polivators."[57] Polivators is a term coined by Lisa Ellman, a partner at the Hogan Lovells law firm, and according to Ellman, is the act of

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[55] Chairman of the Joint Chiefs of Staff, *Joint Concept for Robotic and Autonomous Systems*, 19 October 2016, 22.
[56] Ibid.,8.
[57] *"Polivation" and the Future of Drones*, March 24th, 2016, accessed May 21, 2017, https://www.airmap.com/polivation-future-of-drones.

"policymaking with an eye towards innovation."[58] Armed with a better understanding of ethical assessment criteria and with an eye on emerging technologies, leaders can design innovative-policies that stay ahead of the technology maturation curve. *Polivation* is a term Ellman uses to describe the process of creating these innovative-policies, which are general in scope and provide proactive guidance that serves to support the utilization of promising technologies rather than hinder their implementation. The informed process of *Polivation* will bring the DoD policy maker, engineer, and lawyers to the same table with the common goal of designing future medical strategies that transform readiness, and helps to protect and sustain the future force.[59]

Conclusions

Leveraging robotic, autonomous, or unmanned technologies in life-saving roles present significant opportunities for Department of Defense. Autonomous systems are emerging, and technology is evolving at a staggering rate across a variety of warfighting domains that requires policy makers and strategists to adapt outdated doctrine to enable these new capabilities. The S&T advances in the autonomous unmanned sea, air, land, and robotic surgical systems demonstrate that the DoD can have a capacity to offset the impact on the force that these emerging threats present. The DoD must look to robotic, unmanned, and autonomous systems for helping save lives in D^4Scenarios; these capabilities can reduce risk to the warfighter and can extend a pathway to survival when no other options exist.

In light of these promising technological advances, there is a path set to help overcome the barriers to employing RAS in life-saving roles. The ethical, moral, and legal challenges to

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58 Lisa Ellman, *"Polivation" and the Future of Drones*, March 24th, 2016, accessed May 21, 2017, https://www.airmap.com/polivation-future-of-drones.
59 Lisa Ellman, *"Polivation" and the Future of Drones*, March 24, 2016, accessed May 21, 2017, https://www.airmap.com/polivation-future-of-drones.

this and other future CONOPS can be addressed by using the ethical framework outlined in this presentation. This path also requires educating leaders, polivating, and evolving capability requirements to take advantage of advanced technologies. Strategic synergy occurs by fusing these practices to the ethical foundation that aids in building trust, satisfying the medical professional ethos, and ultimately prepares society and warfare for the exploits of autonomous systems.

Recommendations

1. Accelerate DoD medicine's adoption of autonomous capabilities to ensure proportional life-saving practices overmatch emerging threat systems vis-a-vis A2/AD and austere environments, such as the Arctic. Design policies that will enable the use of unmanned ground, sea, and air vehicles for CASEVAC and medical resupply missions. The DoD should work with the Federal Emergency Management Agency to design CONOPS for using RAS in non-military applications, such as chemical/radiation leaks or natural disasters.
2. Strengthen the operational pull for autonomy in all domains of military medicine by expanding the requirements envelope to include technologies available for conducting CASEVAC missions in the near-term (1-5 years).
3. Polivate to ensure that these RAS systems can be employed in the near term supported by policy and law.
4. Develop a standardized process for evaluating the ethics of emerging technologies as described above. This framework (and others like it) will help leaders in the DoD assess the cost/benefit and help anticipate the effects on society, warfare, and medicine.

5. Provide an exportable training package that educates the DoD on the societal impacts that emerging technologies may have. Include discussions addressing the ethical, moral, and legal implications of using new technologies in life-saving roles.

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